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Percutaneous coronary intervention-lobectomy for Lung Cancer hybrid surgery: an initial case series

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Abstract

Background For patients diagnosed with both lung cancer and severe coronary heart disease (CHD), the conflict between revascularization and lung cancer surgery remains to be settled to balance how to attenuate the cardiovascular risk for lung surgery and shorten the waiting time of anti-platelet therapy after revascularization. This study presents the percutaneous coronary intervention (PCI)-lobectomy for lung cancer hybrid surgery (PLHS), and its antithrombotic therapeutic strategy.

Methods From October 2020 to June 2023, 14 patients, with unstable angina and resectable lung cancer received PLHS. All procedures were performed in a hybrid operating room. Drug-eluting stents (DES) were implanted during PCI. Lobectomy was carried out within one hour after PCI.

Results Procedural success was 100%. All the patients subjected to PLHS were alive after 12 months of follow-up; 2 patients (14.29%) died due to distant metastasis within 12–24 months post-PLHS. There were no intraoperative complications, or 30-day- and 3-month-mortality. Except for one patient who suffered pneumothorax, no other postoperative complications, including severe bleeding, or in-stent restenosis, occurred in the 31.7 ± 10.9 months follow-up.

Conclusions PLHS is a feasible and potentially safe option for patients with both lung cancer and severe CHD.

Keywords Coronary heart disease, Lung cancer, Percutaneous coronary intervention, Lobectomy, Antithrombotic therapy

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Introduction

Cardiovascular diseases (CVD) and cancer are the top two diseases with high morbidity and mortality worldwide. Meanwhile, with the continuous innovation of malignant tumor treatments, such as targeted therapy, the long-term survival rate of malignant tumors has increased yearly, which also led to an increasing coexistence of cardiovascular diseases and malignant tumors [1–3]. How to simultaneously treat the two kinds of diseases is a tough issue in clinics.

Lung cancer remains a significant cause of cancer-related deaths worldwide despite the progress made in cancer diagnosis and emerging treatment methods. The 5-year overall survival rate for lung cancer patients is 19% across all stages of the disease. Lung cancer accounts for 24.7% of new-onset cancers, and accounts for 29.4% of the overall cancer mortality rate in China [3]. About 4.7% of lung cancer is associated with coronary heart disease (CHD) [3], which takes the lives of more than 9.24 million people each year [4]. Current guidelines recommend that patients with lung cancer combined with CHD undergo coronary angiography (CAG) to determine whether to do percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG), aiming to reduce the occurrence of cardiovascular events for unstable CHD patients during the perioperative period [5]. However, dual antiplatelet therapy (DAPT) is required for 30–180 days after PCI, and one year after CABG [6]. During this DAPT period, 26% of lung cancer patients lose the chance of receiving curative resection [7]. This presents a dilemma in the treatment of patients with lung cancer combined with CHD, as untreated unstable severe CHD significantly increases the perioperative risk of lung cancer surgery, while antithrombotic therapy after PCI may delay the timing of lung cancer surgery [8].

PCI-lobectomy for lung cancer hybrid surgery (PLHS) combines the advantages of both PCI and lung cancer resection, shortening preoperative preparation time for cancer surgery, and therefore, may provide a more effective avoidance of tumor malignancy, progression, and metastasis. This pilot study aims to provide a new strategy for patients with lung cancer and severe CHD, providing physicians with the option to shorten the time to surgery and avoid tumor progression.

Methods

Study population

All Patients were from Daping Hospital, from October 2020 to June 2023. Patients under 80 years-old, with lung cancer and lobectomy was indicated. This study included only patients whose intraoperative biopsy met the absolute indications for lobectomy (lesions in stage T1 ~ 3N0 ~ 1M0) [according to the Chinese Guidelines for the Diagnosis and Treatment of Primary Lung Cancer (2022 edition) [9]]. For patients with comorbid coronary artery disease, the degree of stenosis of coronary artery lesion diameter combined with SYNTAX score was used as the basis for decision-making on whether or not to perform PCI.

The inclusion criteria for this study were as follows: Patients with unstable angina symptoms; and (1) lesion diameter stenosis ≥ 90% are eligible for direct PCI; (2) For lesion diameter stenosis < 90%, if the left main diameter stenosis is > 50% and the proximal left anterior descending (LAD) branch stenosis is > 70%, there is evidence of ischemia, or the fractional flow reserve (FFR) is ≤ 0.8; (3) In the absence of FFR testing, stenosis of > 70% of the diameter of any coronary artery with activity-induced angina or equivalent symptoms. (4) Patients with angina who have a SYNTAX score of ≤ 32 for left main lesions and ≤ 22 for three-branch lesions (prefer PCI rather than CABG) [according to 2021 American College of Cardiology/American Heart Association/American Society for Cardiovascular Angiography and Interventions Guidelines on Coronary Artery Revascularization, and 2016 Chinese Guidelines for percutaneous coronary intervention].

Patients with the following conditions were excluded from the study: (1) age > 80 years old. (2) Patient needs total pneumonectomy; (3) CAG showed the degree of stenosis did not reach the criteria for PCI; (4) acute myocardial infarction (ST-elevation/Non-ST-elevation myocardial infarction) within 6 months; (5) lung cancer has pathological results that indicate worsening and metastasizing of cancer for more than 6 months; (6) the stage of lung cancer not operable; (7) pre-anesthesia evaluation shows the cardiopulmonary function cannot meet the scheduled mode of operation; (8) poor general condition, Karnofsky score < 60 and/ or ECOG score ≥ 3; (9) those who did not obtain the informed consent for PLHS.

Study procedure

PLHS was performed in a hybrid operating room. Aspirin 100 mg Qd was given routinely before PLHS. All the CAG was performed through the transradial approach. Before CAG, patients were given 2000 units heparin intravenously. After the PCI was determined to be performed, an initial dose of heparin (80–100 units/kg) was injected intravenously and activated coagulation time (ACT) was maintained > 250s. During PCI, drug-eluting stents (DES) were used for revascularization. If the intervention lasted for more than one hour, an additional dose of heparin at 1000 units would be injected intravenously every other hour. One hour after PCI, the lobectomy would be initiated with routine anesthesia, when ACT < 250s. If the ACT was more than 250s, the surgery procedure should wait for a while or use protamine sulfate for heparin neutralization (1 mg of protamine

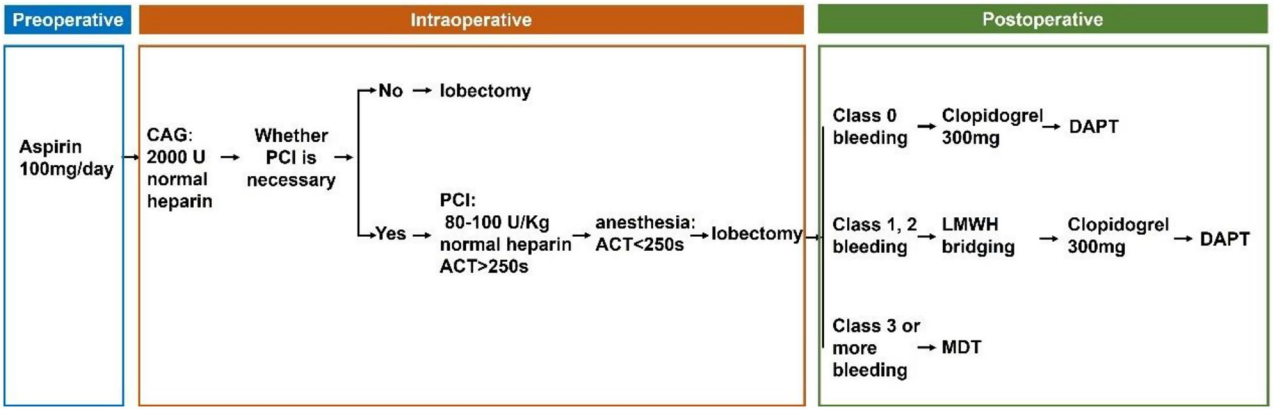

Fig. 1 Clinical pathway of PLHS. ACT: activated coagulation time, CAG: coronary angiography, DAPT: dual antiplatelet therapy, LMWH: low molecular weight heparin, MDT: multidisciplinary team, PCI: percutaneous coronary intervention

Table 1 Patient characteristics

Preoperative parameters		results
Demographic data	Age (years)	67.79±5.36
	Male gender	12 (85.71%)
	Body mass index	23.69±2.80
Risk factors	hypertension	5 (35.71%)
	Hyperlipidemia	5 (35.71%)
	History of smoking	12 (85.71%)
	Diabetes mellitus	4 (28.57%)

neutralizes about 100U of normal heparin). All lobectomies were performed using minimally invasive procedures. Following PLHS, patient bleeding was determined by observing wound, drainage fluid, and hematocrit changes, and postoperative antithrombotic therapy was recommended according to the stages of Bleeding Academic Research Consortium (BARC) bleeding criteria. If no significant active bleeding was observed in the following 24 h, DAPT (aspirin + clopidogrel) would be initiated. If type 1 and type 2 bleeding happened 24 h post-surgery, low-molecular heparin (enoxaparin 1 mg/kg/12 h is preferred) was given to bridge until the bleeding was controlled, then DAPT therapy was initiated. If the patient had type 3 or more severe bleeding, a multidisciplinary team (MDT) was organized to develop a hemostatic and anticoagulant strategy. The clinical pathway is shown in Fig. 1.

Statistical analysis

The results of distribution analysis of continuous variables are presented as mean ± SD. Statistical analyses were performed using GraphPad Prism software (version 10, Dotmatics).

Results

Patient baseline characteristics

Fourteen patients underwent PLHS. Among them, 12 were male and 2 were female; the mean age was 67.79 ± 5.36 years. Five patients (35.71%) had hypertension, 5 patients (35.71%) had hyperlipidemia, 4 patients (28.57%) had diabetes mellitus, and 12 of these patients had a history of smoking (85.71%). Among the coronary lesions, 10 were in three-vessels, 2 were two-vessels, and 2 were single LAD lesions. Among the 14 patients, 4 patients had lung cancer in the left lung and 10 patients had lung cancer in the right lung and the detailed preoperative characteristics are listed in Table 1. A representative lung CT image and pathological image are shown in Fig. 2. After preoperational MDT evaluation, all the patients who were diagnosed with severe CHD complicated with lung cancer, signed the agreement to receive PLHS.

Intra-operative results

All patients had lymph node dissection during surgery (Table 2, more detailed information for each patient is listed in Supplemental Table 1). After resection of tumor tissue, frozen sections were sent for pathological diagnosis and pathological grading (Table 2) to determine that the tumor reached the absolute indications for lobectomy (lesions in stage T1 ~ 3N0 ~ 1M0). All the coronary stents were DES. The results of the CAG and PCI process of a presentative case, which limited severe stenosis in the proximal LAD branch and revascularization after a DES implanted, are shown in Fig. 3. The mean operative time for coronary intervention was 80.79 ± 34.30 min, while the mean operative time for lung cancer resection was 151.07 ± 58.13 min. The total operating time was 231.85 ± 69.64 min. The perioperative bleeding of lobectomy was 250.71 ± 215.67 ml (the highest bleeding volume was 800 ml, and the lowest was 20 ml). The bleeding conditions were measured using BARC scoring:

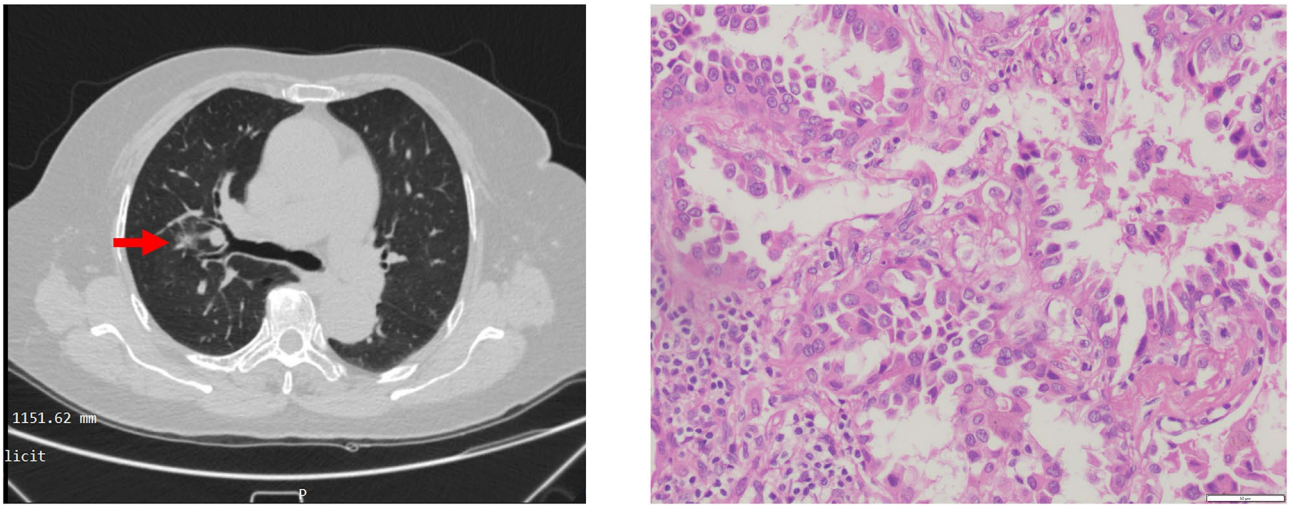

Fig. 2 Chest CT and pathological image of a case. Left: The right upper lung mass was confirmed by chest CT, with irregular enhancement on the edge, indicated by the arrow. Right: The pathological morphology of a tumor tissue after resection (scale bar = 50 μm). The adenocarcinoma was predominantly composed of malignant glandular cells forming irregular shaped acini and papillae

Table 2 The detailed coronary pathology, PCI site, lobectomy site, tumor pathological grading and lymph node dissection in all 14 patients

No.	Gender	Age	CHD pathology	SYNTAX scoring	PCI site	Lobectomy site	Tumor pathological grading	Lymph node dissection	Total operation duration (mins)	intraprocedural complications	On ventilator (hours)	ICU stay (days)	With Pulmonary drainage tube (days)	CAG or CTA re-examined within 12 months post PLHS	Repeated revascularization	Lung CT re-examined within 12 months post PLHS
1	Male	71	LAD (30-75%)+RCA (60-80%)+LCX (30-80%)	16	LAD+RCA+LCX	right upper lobe	pT2aN0, II A	y	255	n	14	3	6	n	n	y
2	Male	62	LAD (50-80%)+RCA (30-50%)+LCX (50-95%)	21	LAD+LCX	right lower lobe	pT2bN2, III B	y	317	n	14	3	8	CAG	n	y
3	Male	72	LAD (50-90%)+RCA (60-90%)+LCX (60%)	19	LAD+RCA	right lower lobe	pT2bN1, II B	y	310	n	5	3	7	CTA	n	y
4	Male	66	LAD (50-85%)	12	LAD	right middle lobe	pT3N0M0, III B	y	150	n	0	0	3	n	n	n
5	Male	78	LAD (30%)+RCA (60-80%)+LCX (75%)	20	LCX+RCA	right middle, lower lobe	pT4N0M0, III A	y	218	n	0	0	2	n	n	y
6	Female	69	LAD (50-95%)+RCA (20-30%)	19	LAD	left upper lobe	pT1N0M0, I A	y	320	n	15	3	5	CTA	n	y
7	Male	77	LAD (40-50%)+RCA (60-80%)+LCX (30-40%)	12	RCA	right upper lobe	pT2N2M0, III A	y	304	n	12	3	7	n	n	y
8	Male	77	LAD (60-80%)+RCA (70-90%)+LCX (70-80%)	22	LAD+RCA+LCX	left upper lobe	pT1bN0M0, I A	n	235	n	4	2	3	n	n	n
9	Male	69	LAD (60-90%)+RCA (60%)+LCX (60-85%)	20	LAD+LCX	right middle lobe	pT2aN0M0, I B	y	225	n	0	0	3	n	n	n
10	Male	79	LAD (60-80%)+RCA (30-40%)+LCX (30-40%)	16	LAD	left upper lobe	pT3N0M0, II B	y	270	n	0	0	2	CAG	n	y
11	Female	74	LAD (10-30%)+RCA (20-85%)+LCX (20-95%)	18	LCX+RCA	right upper lobe	pTisN0M0, II B	y	188	n	0	0	3	CAG	n	y
12	Male	65	LAD (70-80%)	10	LAD	left upper lobe	pT2aNxM0	y	90	n	0	0	2	CAG	n	y
13	Male	64	LAD (85%)+RCA (30-50%)	12	LAD	right upper lobe	pT2aN1M0, IIB	y	235	n	0	0	3	CAG	drug and cutting balloon	y
14	Male	70	LAD (60-85%)+RCA (60-85%)+LCX (60%)	17	LAD	right upper lobe	pT3N0M1a, IVA	y	129	n	0	0	3	n	n	y

2 patients had Type 2 bleeding (14.28%), 2 patients had Type 3a bleeding (14.28%), and 10 patients had Type 1 bleeding (71.44%). No patient had Type 3b or more bleeding. Except for 2 cases of controlled bleeding, no severe intraoperative complications, including acute in-stent thrombosis, coronary plaque rapture, malignant arrhythmia, pericardial tamponade, coronary slow flow, etc. for PCI; Acute respiratory failure, atelectasis, pneumonedema, etc. for lobectomy occurred. (Table 3).

CHD: coronary heart disease, LAD: left anterior descending artery, LCX: circumflex branch of left coronary artery, PCI: percutaneous coronary intervention, RCA: right coronary artery, y: yes, n: no.

Postoperative results

During and following the PLHS, 6 patients (42.86%) were on ventilators, with a mean on-ventilator time of 4.57 ± 6.03 h. The 6 patients (42.86%) on ventilators were transferred to the ICU with a mean ICU days of 1.21 ± 1.42 days. The mean in-hospital days of all the patients was 17.79 ± 6.15 days. All the patients subjected to PLHS were alive 30 days after surgery.(Table 3). One patient developed pneumothorax one month after hybrid surgery.

Follow-up

All the patients who underwent PLHS were alive at 12 months follow-up; 2 patients (14.29%) died due to distant metastasis within 12–24 months post PLHS (Table 4). 11 patients (78.57%) received lung CT every three months for one year after hybrid surgery, which showed no tumor recurrence among these patients within 12 months, 8 patients (57.14%) received coronary angiography or CT angiography (CTA) within 12 months post-PLHS, one

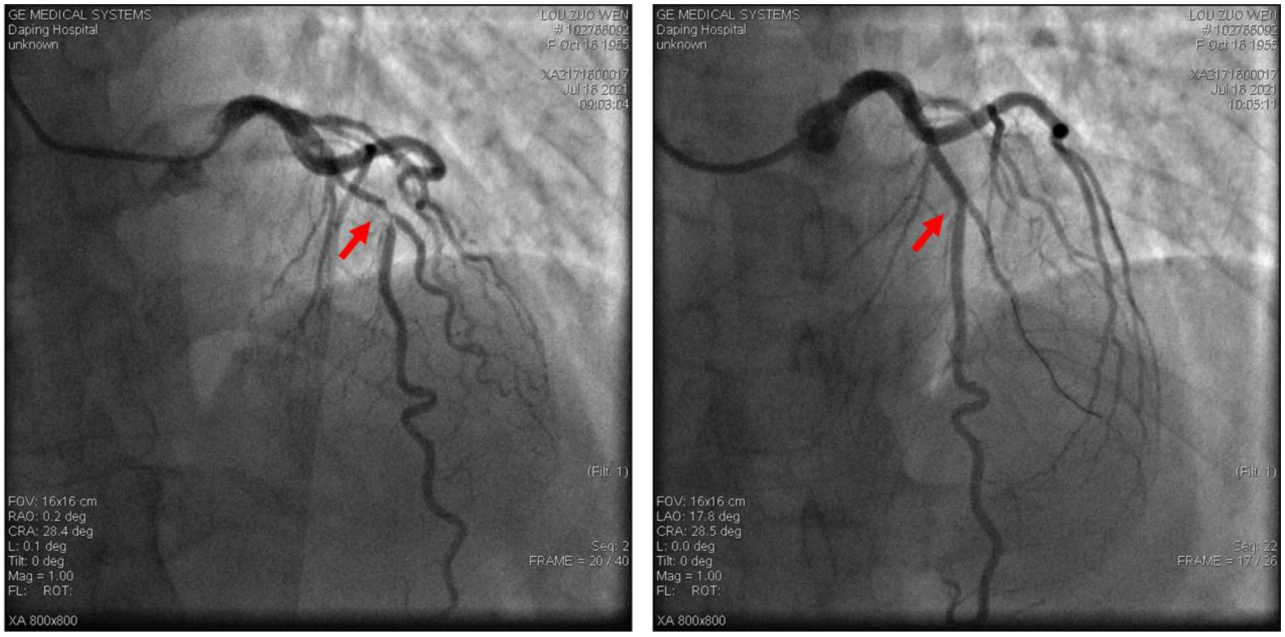

Fig. 3 The coronary angiography in a representative patient before and after PCI. Left image: LAD with 90% stenosis. Right image: LAD after DES implantation. Arrows indicate the location of stenosis before or after DES implantation. LAD: anterior descending branch of left coronary artery, DES: Drug-eluting stents, PCI: percutaneous coronary intervention

Table 3 Operative and postoperative data

Parameters			Results
Operative data	PCI time (min)		80.79±34.30
	Lobectomy time (min)		151.07±58.13
	Total operative time (min)		231.85±69.64
	Perioperative bleeding (ml)		250.71±215.67
	BARC degree	**Type 1**	10 (71.44%)
		Type 2	2 (14.28%)
		Type 3a	2 (14.28%)
		Type 3b or more	0
	Intraoperative complications (bleeding)		2 (14.2%)
Postoperative data	Blood transfusion(red cells suspension)		2 (14.2%)
	Antiplatelet Therapy		Start time (hours post-operation) : 34.28±12.32
			DAPT: 13 (92.8%)
			SAPT: 1 (7.2%)
	On ventilator		6 (42.86%)
	On ventilator time (hours)		4.57±6.03
	Transfer to ICU		6 (42.86%)
	ICU stay (days)		1.21±1.42
	Hospital stay (days)		17.79±6.15
	30-day mortality		0

BARC: Bleeding Academic Research Consortium, ICU: intensive care unit, PCI: percutaneous coronary intervention, DAPT: Dual Antiplatelet Therapy, SAPT: Single Antiplatelet Therapy.

patient had in-stent restenosis (7.14%), and repeated revascularization using DCB (drug-coated balloon). No significant bleeding and no major adverse cardiovascular events (MACE) occurred following the antithrombotic treatment strategy. There was 31.7 ± 10.9 months follow-up as of June 30, 2024,.

Table 4 Follow -up data summary

Parameters		Results	
Follow-up data	Follow-up rate	100%	
	12 months mortality	0	
	24 months mortality	2 (14.29%)	
	MACE	0	
	HFrEF (LVEF<40%)	0	
	Postoperative complications	2 (14.29%)	Pneumothorax: 1
			Massive drainage: 1
	CAG or CTA re-examined	8 (57.14%)	
	In-stent restenosis	1 (7.14%)	
	Re-revascularization (DCB)	1 (7.14%)	
	Lung CT re-examined	11 (78.57%)	
	12 months recurrence of lung cancer	0	
	24 months recurrence or distance metastasis	recurrence: 0	
		distance metastasis: 2 (14.29%)	

CAG: coronary angiography, CTA: computed tomography angiography, MACE: major adverse cardiovascular events. HFrEF: heart failure with reduced ejection fraction，LVEF：left ventricular ejection fraction，DCB: drug coated balloon.

Discussion

When patients suffer from both severe CHD and lung cancer which requires surgery for cure, the treatment strategy is a major challenge, related to the timing of both lung cancer resection and coronary revascularization. In case of high perioperative cardiovascular risk, the standard approach has been coronary revascularization first, followed by 30–180 days of DAPT for PCI and 2–8 weeks of DAPT for CABG [6], which will delay the time for cancer surgery. Unfortunately, previous studies have shown that the doubling time of non-small cell lung cancer (NSCLC) cells with different degrees of differentiation and histological types ranges from 33 to 183 days, with a median time of 54 days, leading to an increasing of the cancer mass up to 373% [9]. Previous literature has shown that 26% of lung cancer patients lose the chance to receive radical resection due to antithrombotic therapy [7]; while performing lung cancer resection without preoperative coronary revascularization of severe coronary lesions would lead to increased perioperative risk events, such as myocardial infarction, malignant arrhythmias, and cardiogenic shock [2].

Cardiologists and pulmonologists have worked together to shorten the surgical waiting time for patients with severe CHD and lung cancer, and hybrid surgery may provide an optimal option for this dilemma. In 1980, Bricker DL first reported simultaneous CABG and lung resection [10]. Subsequently, a retrospective analysis of concurrent cardiac surgery and pneumonectomy in patients with lung cancer conducted by MH Danton et al. showed 2- and 5-year survival rates of 62% and 42%, respectively, and they concluded that lobectomy can be safely performed in patients undergoing concurrent cardiac surgery with a high long-term survival rate [11]. A successful case of left upper lung lobectomy performed 8 days after balloon dilatation of the coronary artery was reported in 1990 [12], initiating the combination of coronary intervention with pneumonectomy. In 2007, Tsuchida et al. reported another successful case of lobectomy done after 5 days of PCI of the coronary artery [13], promoting us to build a novel procedure that combines PCI and lobectomy.

In this study, we presented the PLHS, using PCI combined with lobectomy, that may not only reduce the perioperative risk of myocardial infarction, shock, and sudden death, but also shorten the waiting time for lung cancer surgery during DAPT. At the time of initiation, this study followed "2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery" [5], and the "2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization" [6]. The update of the Guideline [14] stated that "In patients with non–left main CAD who are planned for non-cardiac surgery (NCS), routine preoperative coronary revascularization is not recommended to reduce perioperative cardiovascular events." The evidence mainly comes from the randomized controlled trial "Initial invasive or conservative strategy for stable

coronary disease" [15]. The population enrolled in the study by Maron DJ [15] et al. were patients with stable coronary disease, whereas all of the 14 patients included in our study had preoperative anginal symptomatic changes, which was considered as unstable angina pectoris, rather than patients with truly stable chronic coronary disease (CCD). Of course, with the updating of the guidelines, whether or not patients with unstable CHD who require non-cardiac surgery can benefit from preoperative coronary revascularization and what the criteria for revascularization is also a series of topics worthy of further study.

The antithrombotic treatment strategy is the central part of this study, the CRUSADE bleeding score and the GRACE ischemia score are recommended to help adjust the use of anticoagulation and DAPT based on the patient's individual characteristics. Aspirin and clopidogrel remain the first choice for dual antiplatelet therapy for PLHS procedures, while indobufen is an alternative, used in patients with gastrointestinal bleeding with or without aspirin administration. Ticagrelor is not recommended at this time because of its stronger antiplatelet effect and potential increased risk of bleeding. A meta-analysis of 41 studies by Burger et al. [16] showed that aspirin treatment was associated with a 1.5-fold increase in postoperative bleeding events, but not in the severity of bleeding. Therefore, due to the comprehensive effect on the balance between increased bleeding and reduced cardiovascular events, routine administration of aspirin 100 mg/day is still recommended for patients in this regime. The 2023 AHA/ACC/ACCP/ASPC/NLA/PCNA Guideline [17] states that aspirin and/or clopidogrel should be resumed approximately 24 h postoperatively, provided effective hemostasis is achieved (Class 2 C). In consideration of this suggestion, we recommend resuming clopidogrel if the score of BARC is lower than Type 2. In this study, 12 of the 14 patients met this condition, two had manageable BARC Type 3a bleeding and underwent suspension of red blood cell infusion, 1U and 3U respectively. Patients with BARC Type 1 and 2 were initiated with a standard dose of dual antiplatelet therapy (DAPT) at 24–48 h postoperatively based on bleeding volume, postoperative drainage, and use of chemotherapeutic agents, and the 2 patients with Type 3a, who had suspension of red blood cell infusion, were initiated with MDT discussion, in which one patient with smaller bleeding volume and drainage volume initiated standard dose DAPT at 48 h postoperatively, and the other patient with larger postoperative drainage volume was determined to be given 50 mg clopidogrel single antiplatelet therapy at 48 h postoperatively after MDT discussion. The development of an antithrombotic strategy, which is the central aspect of this study, is challenging in PLHS, and we must have a good balance between the risk of bleeding and thrombotic events, in which MDT-based personalized treatment is essential. It may provide clinicians with new treatment concepts, as well as new clinical treatment options for the increasing number of patients with lung cancer combined with severe coronary artery disease.

Limitation

This study was conducted in a single center only, with a very small sample size at present, and the conclusions drawn are of informative value only. Clinical decisions regarding patient inclusion and exclusion criteria, the selection of antithrombotic strategy, and with the updating of the guidelines, whether patients with unstable CHD who require non-cardiac surgery can benefit from preoperative coronary revascularization still require further input from multicenter randomized controlled studies.

Conclusion

Our case series indicates that the lung cancer hybrid surgery provides a potentially safe and time-saving approach for patients with both severe degrees of coronary stenosis and surgically treatable lung cancer. Although the safety of the current anti-platelet regimen was shown in the present study, it still needs to be confirmed in more cases in clinics in the future.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40959-025-00317-6.

Supplementary Material 1

Author contributions

C.Z. and G.W. designed and supervised the study with input from J.Z. and B.D., J.Z, and G.W. performed the percutaneous coronary intervention (PCI) operations, Y.Y., T.Z., L.M., Y.H., and B.D. performed the lobectomies of the hybrid surgery. J.Y., J.Z., and Q.M. collected the clinical data, Q.M., and L.H. participated in the follow-ups, J.Y., and G.W. drafted the manucaript. C.Z. reviewed the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval

This study was approved by the Medical Ethics Committee of the Daping Hospital of the Third Military Medical University. Informed consent was obtained from each participating patient.

Competing interests
The authors declare no competing interests.

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